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Final Technical Report (A 004)
and
Test and Demonstration Report (A 002)

Investigation of Neurophysiological Procedures for the Detection of Explosives

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Summary

The purpose of this study was to determine whether rats, exposed to the odors emanating from TNT, demonstrate differential cortical frequency spectra (CFS) if these odors are reinforced by electrical brain stimulation (EBS) in the medial forebrain bundle (MFB).

Forty three male albino rats, were surgically prepared by stereotaxically implanting a bipolar, stainless steel, stimulating electrode into the MFB, and attaching two cortical surface electrodes for recording CFS.

Each rat comprised an individual experiment, in which various procedures of stimulus delivery (e.g., manually changing tubes of TNT and control odorants, versus automatically switching compressed air through the tubes), training (using operant conditioning in some as an index of conditioning versus classical conditioning), and analyses of the results were employed to answer the basic question of whether rats can discriminate TNT.

Except for several rats who died (from ingesting toxic matter), or lost their electrical skull caps, almost every rat showed: (a) behavioral, (b) neurophysiological, or (c) both behavioral and neurophysiological indices of the ability to respond differentially to the odorants emanating from TNT in contrast to control odorants (e.g., asphalt, pine sawdust, room air). The behavioral indices comprised pressing a bar to receive an EBS when TNT was present and to refrain from such behavior in the presence of the control odorants. The neurophysiological indices were changes in the CFS obtained during TNT stimulation in comparison with CFS obtained prior to training or during control odorant stimulation.

The conclusion can be clearly stated: Rats can demonstrate the presence of TNT by modification of their brain response or, behaviorally, by pressing a bar.

Introduction

Since the purpose of this study was to determine whether rats can detect the odors emanating from TNT, our major efforts were to devise various procedures which would test this hypothesis. Therefore, each rat comprised an individual experiment, in which variants of the following were employed: 1. stimulus delivery systems 2. operant conditioning as an index of conditioning before brain-recordings were taken 3. classical conditioning procedures, and 4. analytic procedures involving various filtering systems, and statistical analyses.

The major aspect of this report, therefore, will deal with a description of how each rat was trained, the variants of his training procedures and the relative level of training effected, since, in essence, the question of <u>whether</u> rats can detect TNT has been answered affirmatively.

Further sections in (Appendices contain all the technical data: Surgical Procedures, Shaping Procedures, Conditioning Procedures, Analysis of Effect, Subjects not Completed, 26 Band EEG Frequency, and Summary Information.

The section immediately following contains a description of each rat's "Status," (i.e., level and type of conditioning), EBS data, Intensity-Rate Curve, Odorants Employed, and Conditioning (including data on operant responses where applicable). There is also a page giving, for each rat, per cent time in each CFS band pre- and postodorants, six correlations between these CFS, and nine T tests comparing the level of the correlations. The differences between various correlations are one index of training by detecting nonlinear changes in the spectral distribution of the CFS under TNT and any of the following: pre-TNT, pre-Non-TNT, or Post Non-TNT. The Wilcoxon and Friedman Tests were employed as indices of greater or lesser degrees of cortical activity across the entire spectral distribution.

In each rat, correlations between the CFSs obtained under exposure to TNT odorants and under exposure to non TNT odorants both before and after conditioning were statistically compared. A statistically significant ($p<.05$) decrease in the correlation between the CFSs obtained during post conditioning exposure to TNT and another condition was taken as sufficient evidence of conditioning. The data which follow include the CFSs (percent time in band) for each conditioned rat for: pre conditioning exposure to TNT odorants, (Pre-E), post conditioning exposure to TNT odorants, (Post-E), preconditioning exposure to NTNT odorants (Pre-NE), and post conditioning exposure to Non TNT odorants (Post-NE).

Pearson Product Moment Correlation: r_1=PreNE-PreE; r_2=PreNE-PreE; r_3=PreNE-PostE; r_4=PreNE-PostNE; r_5=PreE-PostE; r_6=PostNE-PostE.

t-test #	Between r_s	Control r_s
1	1, 5	3
2	1, 3	5
3	2, 6	3
4	2, 3	6
5	4, 5	6
6	4, 6	5
7	2, 5	-
8	4, 3	-
9	1, 6	-

S OOO

Status. This rat was conditioned to bar-press to the odor of TNT ($p < .01$). He died before brain recordings were taken.

EBS Rate and Parameters. The current parameters were: 300μ A for 250 msec. He pressed 35/min.

Intensity-Rate Curve. This was not computed.

Odorants Employed. Preconditioning odorants were: TNT, pine dust, and asphalt: postconditioning odorants were the same ones.

Conditioning. Odorants changed manually for each trial. Varied VI schedule of reinforcement during training session, one minute trials. (see Tables). Later (4/21/76) on revised automatic system w/solenoid air valves, probability generator, etc., clicks signalling TNT, light for ITI, 50 second trial, 10 sec. ITI, session time-60 min. Passed stage 1 (learned clicks), died shortly thereafter.

Total No. of Sessions: ?

Pine Sawdust vs. TNT

1/28/76
1 min. trials
Varied VI

	Ex	NEx	
R	30	22	52
NR	0	16	16
	30	38	68

$X^2 = 14.3$
$p < .001$

1/30/76
First 25 min. of 50 min. trial

	Ex	NEx	
R	12	7	19
NR	0	6	6
	12	13	25

$X^2 = 5.0$
$p < .1$ (1 tail)

2/3/76

	Ex	NEx	
RE	2	2	4
NoRE	15	17	32
	17	19	36

Pseudo-control
Non Significant:
(No TNT in tube by error)

S 004

Status. 1. Behaviorally conditioned $p < .0001$. 2. Brain conditioned (Friedman Test) $p < .053$.

EBS Rate and Parameters. 195/min. 175 μA x 200 msec.

Intensity-Rate Curve.

50 μA	60/min/
75 μA	116.3/min.
100 μA	154/min.
125 μA	159.2/min.
150 μA	179.5/min.
175 μA	195/min. → optimal
200 μA	194.5/min.

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt, Pine, Air

Conditioning. 1. 50 second trials, 10 second ITI, TNT vs. Asphalt (3/5/76)

2. 20 second trials, 10 second ITI, clicks to signal TNT, ITI light, Hiss with bar press during NE (4/14/76); Passed clicks phase, 50% RF schedule.

3. Continuance trials: Press-trial extended; 3 second delay at beginning of trial to onset of stimulus, then 4.3 second chance to respond. Response= extend trial to 12 seconds, No Response= end of trial, into ITI. 1/2 hr. sessions, 2x a day. Conditioned (6/7/76) on this system after 34 previous sessions, including previous systems. RF schedule: 100%.

Note: Ran after 7 weeks dormancy on different system, different odor, different air-vacuum system; very significant (see below)

Total No. of Sessions: 34

6/21/76
continuance trials

	R	NR	
E	53	6	59
NE	0	33	33
	53	39	92

$X^2 = 69.9$
$p < .0001$

6/24/76
continuance trials

	R	NR	
E	56	1	57
NE	0	29	29
	56	30	86

$X^2 = 81.7$
$p < .0001$

8/17/76
after 7 weeks dormancy on 20 sec. trials (constant) no continuance trials no punishment very few mistakes, no objective data taken

8/18/76
same as above: NE-air;
classical logic circuit

	Re	No Re	
Ex	32	0	32
NEx	6	22	28
	38	22	60

$X^2 = 39.7$
$p < .0001$

8/19/76
NE=pine
New air-vacuum system

	NE	Ex	
Re	8	27	35
NR	19	0	19
	27	27	54

$X^2 = 29.3$
$p < .0001$

SUBJECT NO. 04

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	0	0	0	5
2	0	5	1	1
3	3	0	3	1
4	1	0	3	4
5	4	4	2	4
6	5	0	3	2
7	15	13	7	10
8	13	21	11	11
9	9	5	6	7
10	7	4	5	5
11	5	4	2	4
12	5	5	3	4
13	3.1	2.1	2.6	5
14	2	1.9	3.2	4.2
15	2.1	0	1.9	4.4
16	1.1	3.1	1.6	1.8
17	1.2	1.5	2.1	1.2
18	1.1	2.7	1.6	1.3
19	1	3.2	1.4	1
20	1.2	1.2	1.3	1.8
21	1.9	1.6	2.3	1.1
22	1.8	1.9	2.6	1.9
23	1.2	1.7	2.1	1.9
24	1.8	.5	2.1	2.2
25	1.1	2.7	1.9	1.9
26	1.6	1.7	1.9	2.6

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .813895
PRE-NF VS POST-NF
CORR= .881117
PRE-NF VS POST-F
CORR= .855152
PRE-F VS POST-NF
CORR= .826964
PRE-F VS POST-F
CORR= .763145
POST-NF VS POST-F
CORR= .817874

COND	T
1	.798383
2	-.63276
3	1.23498
4	.501302
5	.936274
6	.131341
7	1.27859
8	-.327465
9	-.403644E-01

S 005

Status. Brain conditioned $p < .001$ on Behavioral Conditioning. (Correlation)

EBS Rate and Parameters. 40/min. 475μ A x 250 msec.

Intensity -Rate Curve.

	400μ A	32/min.
	450μ A	35/min/
optimal ---→	475μ A	39.8/min.
	500μ A	stopped pressing

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. 1. 4/14/76; clicks on TNT, yellow light flash on press during NE, 50 second trial, 10 second ITI, 60 min. session once a day. Dropped ITI light and punishment, passed clicks after 8 sessions. 2. 4/30/76; started fading clicks over sessions, tried 20 second delay to onset of clicks. 3. 5/28/76; on continuance trials; 3 second reinforcement delay after odor; 20 second chance to press; Press=60 sec. trial, No Press = end trial. Final system used; looked good when pressing, but took long breaks. Session shortened to 30 minutes. Never passed behaviorally, Recorded EEGs - Brain Conditioned.

Total No. of Sessions: 38

S 006

Status. Brain conditioned $p < .001$ (correlation) Instrumental and Classical. Behaviorally conditioned $p < .1$ (Chi-square)

EBS Rate and Parameters. 25/min. 600μ A x 500 msec.

Intensity-Rate Curve.

	575μ A	13/min.
optimal ---→	600μ A	25/min.
	625μ A	18.6/min.

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt, Air

Conditioning. 1. 4/14/76; Ex-clicks, NE-yellow light flash w/press, ITI = yellow light, 20 sec. trial, 10 sec. ITI, 30 min. session. Learned clicks, started fading clicks 21 sessions. 2. 5/28/76; Continuance trials; 3 second R_f delay, 20 second chance to respond; Response 60 sec. trial, learned at $p < .1$ level.
3. Insignificant Brain Waves, switched to classical conditioning. 7/23/76. Intensity lowered to 425μ A because of convulsions. 20 second trials, 10 second ITI, 30 min. sessions= 60 trials/day. 100% R_f schedule; Brain Conditioned after 5 sessions classical.

Total No. of Sessions. 38

SUBJECT NO. 05

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	3	2	5	0
2	0	3	2	0
3	4	4	0	0
4	2	5	3	0
5	5	4	6	0
6	5	3	1	0
7	11	13	5	1
8	9	12	8	4
9	9	5	11	0
10	4	7	9	2
11	4	3	6	0
12	4	4	4	1
13	4.2	5.3	3.3	2.6
14	4.6	2.6	3	3
15	3.4	2.1	5	3.2
16	2.1	2.1	1.7	2
17	2.1	.5	1.4	2.3
18	1.1	1.1	1.7	.4
19	1.2	1.7	3.2	3.2
20	1.5	1.4	1.3	1.8
21	1.7	2	1.5	1.3
22	2.8	1.8	2.1	1.5
23	1.3	1.8	2.3	1.6
24	2.3	2.2	2	2.2
25	3.2	1.9	1.9	.6
26	2.[illegible]	2.3	2.3	3

STATISTICAL DATA

		COND	T
PRE-NF	VS PRE-F	1	4.26492
CORR=	.816671	2	4.97898
PRE-NF	VS POST-NF	3	2.60052
CORR=	.631856	4	2.72640
PRE-NF	VS POST-F	5	1.83101
CORR=	.220[illegible]E-01	6	2.17183
PRE-F	VS POST-NF	7	2.15538
CORR=	.548[illegible]	8	2.01305
PRE-F	VS POST-F	9	3.74491
CORR=	.10845[illegible]		
POST-NF	VS POST-F		
CORR=	.42303E-01		

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SUBJECT NO. 08

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	42	31	36	26
2	7	24	24	7
3	14	24	8	5
4	22	13	14	16
5	4	6	6	11
6	3	3	3	15
7	18	17	18	25
8	20	15	14	14
9	11	14	7	7
10	7	8	6	
11	5	4	5	1
12	9	10	4	5
13	6.6	7.9	5.3	4.6
14	11.3	10.1	6	4.5
15	5.8	6.4	7.4	8.5
16	2.9	3.9	2.9	2.9
17	2.8	3.2	4.6	5
18	3	3	4.2	4.2
19	.8	5.3	4	5.9
20	4.7	5.5	5.1	6.0
21	5	5.6	7	6.3
22	6	6	9.9	7.2
23	6.7	12.4	10.8	9.4
24	8.8	9.6	14.3	11.5
25	8.3	4.9	8.3	8.1
26	4.9	7.9	4.8	3.9

STATISTICAL DATA

		COND	T
PRE-NF	VS PRE-F	1	2.51881
CORR=	.780074	2	-.126481
PRE-NF	VS POST-NF	3	1.31959
CORR=	.831517	4	.532486
PRE-NF	VS POST-F	5	2.7567
CORR=	.79214	6	.8437
PRE-F	VS POST-NF	7	1.84469
CORR=	.413545	8	.214225
PRE-F	VS POST-F	9	.962856
CORR=	.571038		
POST-NF	VS POST-F		
CORR=	.735536		

S 014

Status. Brain conditioned, $p < .005$ (correlation), classical

EBS Rate and Parameters. 46/min. 225μ A x 250 msec.

Intensity-Rate Curve.

150μ A	18/min.
175μ A	26.4/min.
200μ A	33.8/min.
225μ A	45.7/min.
250μ A	motor movement, stops pressing

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. 1. 7/2/76 - started on Classical Conditioning 20 second trials, 10 second ITI, 30 minute sessions, = 60 trials/day. Recorded after 5 and 10 sessions. Brain conditioned after 10 sessions.

Total No. of Sessions. 10

S 016

Status. Brain conditioned, $p < .01$ (correlation)

EBS Rate and Parameters. 26/min. 400 μ A x 250 msec.

Odorants Employed. Pre: TNT, Asphalt, Pine, Air - Post: TNT, Pine

Conditioning. Standard Classical. 20 sec. trials, 10 sec. ITI, 30 min. session once a day = 60 trials/day.

Behavioral note. began to spend most time sniffing at air during each progressive session.

Brain conditioned after 4 sessions.

R_f schedule - 100%, 50% during session prior to post recording

* Lost original cap, reoperated on to replace.

Intensity-Rate Curve.

used for conditioning →	350μ A	19/min.
	375μ A	20.4/min.
optimum →	400μ A	26/min.
	425μ A	18/min.

Total No. of Sessions 4

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	42	26	18	31
2	18	20	24	17
3	22	29	29	17
4	21	16	20	7
5	13	11	11	8
6	10	6	6	3
7	10	9	25	12
8	21	13	20	11
9	18	20	6	18
10	14	14	3	9
11	8	11	2	6
12	11	11	7	11
13	4.1	4.1	5.3	11.2
14	5.6	6.9	4.2	7.1
15	5.5	3.7	5.3	4.2
16	2.1	1.7	3.9	1
17	2	1.6	2.8	2.8
18	1.1	1.4	2.1	.4
19	1.4	2.6	3.6	0
20	2.2	2.4	2.5	6.5
21	2.1	2.3	7.6	6.3
22	2.5	2.1	8.1	6.6
23	1.9	2.2	8.6	7.6
24	1.9	3.1	7.9	8.6
25	3.2	2.8	7.5	7.5
26	1.9	1.6	3.7	5.1

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .907381
PRE-NF VS POST-NF
CORR= .611147
PRE-NF VS POST-F
CORR= .846543
PRE-F VS POST-NF
CORR= .602723
PRE-F VS POST-F
CORR= .81855B
POST-NF VS POST-F
CORR= .586403

COND	T
1	1.87774
2	1.27634
3	.471618
4	-2.3499
5	-2.02718
6	.747649
7	-1.49755
8	-1.85298
9	2.94128

SUBJECT NO. 16

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	26	21	42	42
2	10	17	10	3
3	17	26	11	11
4	11	14	20	27
5	11	10	8	13
6	8	4	10	6
7	19	17	10	14
8	18	18	22	15
9	12	11	14	15
10	7	3	6	7
11	5	5	2	4
12	4	2	0	0
13	3.9	7.2	7.2	15.8
14	6	5	6.5	8.9
15	8.5	9	7.9	7.4
16	2.9	2	3.9	3.9
17	4.1	2.3	4.6	2.8
18	4.7	2.1	.8	3
19	5.9	5.1	1.6	2.4
20	9.4	3.6	7.6	6.5
21	5.6	9.3	7.3	7
22	10.2	11.4	8.7	8.1
23	11.1	9.2	10.2	7
24	11.5	9.1	8.1	6.4
25	8.5	7.7	7.9	4.8
26	5.9	4.8	5.6	3

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .820667
PRE-NF VS POST-NF
CORR= .915061
PRE-NF VS POST-F
CORR= .726712
PRE-F VS POST-NF
CORR= .617635
PRE-F VS POST-F
CORR= .593219
POST-NF VS POST-F
CORR= .908602

COND	T
1	2.5494
2	1.02324
3	-1.72553
4	1.71307
5	.349908
6	-3.50977
7	1.55742
8	-.686104
9	-1.22387

S 017

Status. Brain conditioned. $p < .01$ (correlation)

EBS Rate and Parameters. 97/min. 200 μA x 250 msec.

Intensity-Rate Curve.

	100 μA	57.7/min.
	125 μA	84.2/min.
used for conditioning →	150 μA	88.2
	175 μA	91.5/min.
optimum →	200 μA	97/min.
	225 μA	90/min.

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical

20 second trials, 10 sec. ITI, 30 min/session, 1 session/day = 60 trials/day - Recorded after 6, 11, and 14 sessions - Brain conditioned after 14 sessions. - Reinforcement schedule: 100%, 50% during session preceding post recordings.

Total No. of Sessions. 14

S 019

Status. Brain conditioned ($p < .01$ - Friedman - $p < .005$ - Correlation)

EBS Rate and Parameters. 108/min. 275 μA x 250 msec.

Intensity-Rate Curve.

200 μA	82/min.
225 μA	100/min.
250 μA	104/min.
275 μA	108/min.
300 μA	100/min.

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical

20 second trials, 10 second ITI, 30 min. session, 1 session day = 60 trials/day. Post recordings after sessions 3, 5, and 10. Brain conditioned after 10 sessions.

Total No. of Sessions. 10.

SUBJECT NO. 17

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	21	26	10	42
2	30	21	3	14
3	20	20	28	23
4	24	20	7	9
5	13	8	13	11
6	2	5	2	2
7	11	22	14	19
8	26	17	23	19
9	10	6	14	15
10	5	3	7	9
11	3	5	2	2
12	10	10	13	4
13	5.9	5.3	5.9	5.3
14	9.5	4.2	7.1	10.7
15	5.3	6.9	5.8	6.9
16	4.9	4.9	3.9	2.4
17	4.1	4.5	1.8	.4
18	2.6	6	3	5.5
19	4	4.4	2.8	2.8
20	8.7	5.8	4.4	5.1
21	7	6	5.3	9.6
22	8.7	9	7.8	7.2
23	10	7	10.2	11.4
24	9.3	6	9.8	7.9
25	7.3	5.6	8.7	9.4
26	7.4	6.2	3.7	6

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .809113
PRE-NF VS POST-NF
CORR= .431836
PRE-NF VS POST-F
CORR= .592363
PRE-F VS POST-NF
CORR= .497984
PRE-F VS POST-F
CORR= .79164
POST-NF VS POST-F
CORR= .580302

COND	T
1	.322678
2	2.69285
3	-.977124
4	-1.05249
5	-2.38968
6	-.73635
7	-1.99203
8	-.456707
9	1.56514

SUBJECT NO. 19

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	5	0	0	0
2	14	5	7	0
3	11	13	11	9
4	11	13	0	[illegible]
5	4	[illegible]	8	3
6	13	[illegible]	2	10
7	10	[illegible]	7	16
8	4	[illegible]	11	5
9	4	[illegible]	0	[illegible]
10	3	3	2	3
11	1	2	6	4
12	0	2	6	4
13	2	2.4	2.6	5.3
14	1.2	2.8	4.2	4.8
15	1	1.6	2.6	6.8
16	.5	1	.5	1.6
17	1.4	.8	.4	2.2
18	.4	.7	.4	2.7
19	0	.8	.8	.6
20	.4	.2	1.1	2.3
21	1	.7	1.3	1.6
22	.3	.7	1.2	2.4
23	1.1	.8	1.3	1.8
24	.7	.4	1.4	1.1
25	.4	.3	2.5	1.7
26	.5	.4	1	1.7

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .765491
PRE-NF VS POST-NF
CORR= .539835
PRE-NF VS POST-F
CORR= .392744
PRE-F VS POST-NF
CORR= .796618
PRE-F VS POST-F
CORR= .420335
POST-NF VS POST-F
CORR= .379104

COMP	T
1	2.38362
2	2.59954
3	.850999
4	.774961
5	2.74168
6	3.08719
7	.528427
8	2.28695
9	2.06974

S 020

Status. Brain conditioned $p < .001$ (correlation) Behavioral
Behaviorally conditioned $p < .001$ (Chi-square)

EBS Rate and Parameters. 130/min. 300 μ A x 250 msec.

Intensity-Rate Curve.

120 μ A	13/min.
150 μ A	23/min.
200μ A	93.5/min.
225μ A	106/min.
250μ A	113/min.
275 μ A	118/min.
300μ A	131/min.
325 μ A	134/min. ← optimal
350 μA	120/min.

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Behavioral (Instrumental)

1. 15 minute sessions, 2 x a day, 50 second trials, 10 second ITI (5/10/76) clicks for TNT, no punishment; yellow light = ITI 17 sessions.
2. 5/28/76 - switched to continuance trials; 3 second R_f delay, 6 second chance to respond; Response=20 second trial, No respons = end of trial, into ITI. 36 sessions.

Learned, behaviorally, $p < .001$, combining 4 consecutive 15 minute sessions; Recorded, brain conditioned. (see below)

6/24/76
3 days, 4 consecutive sessions.
Continuance trials
20 second trial if responded;
10 second ITI

TNT vs. Asphalt

	NE	E	
Re	119	141	260
NRe	13	1	14
	132	142	274

$X^2 = 11.79$
$p < .001$

Total No. of Sessions . 53

S 021

Status. Brain conditioned $p < .005$ (correlation)

EBS Rate and Parameters. 30/min. 450 μ A x 250 msec.

Intensity-Rate Curve.

350 μ A	14/min.
400 μA	26/min.
optimal, → 450 μ A	30/min.
375 μ A used in conditioning. 475 μ A	25/min.

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical 20 second trial, 10 sec. ITI, 30 minute sessions, 1 session/day = 60 trials/day. Post recorded after 5 and 16 sessions, brain conditioned after 16 sessions.

Total No. of Sessions. 16 .

SUBJECT NO. 20

PERCENT TIME IN BAND

BAND	PRE-NE	PRE-E	POST-NE	POST-E
1	0	0	0	5
2	2	1	0	3
3	2	8	3	6
4	7	7	9	4
5	9	5	8	11
6	4	7	3	3
7	13	13	8	10
8	17	9	13	7
9	6	7	9	15
10	5	2	7	4
11	3	2	5	1
12	2	2	4	3
13	2.6	1.8	3.9	1.3
14	2	2.4	.6	1.2
15	2.8	2.5	3.7	1.6
16	1.5	1.3	1.7	1.5
17	.9	1.4	.9	1.4
18	1.4	1.4	.4	.4
19	.9	1.3	.8	.4
20	1.6	1.4	1.6	.7
21	1.9	1.4	1.3	1.3
22	1.7	2.1	.9	1.2
23	2.2	1.2	2.3	2.2
24	1.8	2.3	2	1.2
25	1.4	1.7	2.5	1.4
26	1	1.5	1.9	1.4

STATISTICAL DATA

		(COND)	T
PRE-NE	VS PRE-E	1	.795265
CORR=	.775[illegible]	2	1.28893
PRE-NE	VS POST-NE	3	2.64568
CORR=	.890482	4	3.28732
PRE-NE	VS POST-E	5	-.431279
CORR=	.646578	6	-.412673
PRE-E VS	POST-NE	7	1.9233
CORR=	.646624	8	.2726725-03
PRE-E VS	POST-E	9	.620025
CORR=	.694759		
POST-NE	VS POST-E		
CORR=	.691523		

SUBJECT NO. 21

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	2	2	21	11
2	2	2	7	7
3	7	4	10	10
4	4	4	12	7
5	6	5	2	5
6	3	3	2	3
7	10	12	8	3
8	9	9	5	11
9	7	7	6	5
10	3	4	2	3
11	3	3	1	3
12	4	3	1	3
13	3.1	3.1	1.6	1.6
14	3.6	2.3	.6	.9
15	2.9	5.8	1.6	1.8
16	1.5	1.5	.2	.2
17	1.2	1.2	.2	.9
18	1.7	1	1.3	.8
19	1.7	2.5	1.4	1.8
20	2.2	1.7	.2	.7
21	2.8	2.3	.8	.8
22	2.4	1.7	1.5	1.2
23	2.7	1.9	.7	1.6
24	1.4	2.4	1.2	.6
25	1.9	1.5	.8	1.7
26	2	1.9	1	1

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .8399[illegible]

PRE-NF VS POST-[illegible]
CORR= .306811

PRE-NF VS POST-[illegible]
CORR= .539427

PRE-F VS POST-NF
CORR= .234262

PRE-F VS POST-F
CORR= .358548

POST-NF VS POST-[illegible]
CORR= .782479

COND	T
1	4.52981
2	2.65635
3	-3.91291
4	-2.05005
5	-.971139
6	-3.73971
7	-.197358
8	-1.23659
9	.573542

S 022

Status. Brain conditioned, $p < .025$ (correlation)

EBS Rate and Parameters. 131/min. 225 μ A x 250 msec.

Intensity-Rate Curve.

100 μ A	62/min.	
125 μ A	74/min.	
150 μ A	95/min.	→ used for conditioning
175 μ A	110/min.	
200 μ A	128/min.	
225 μ A	131/min.	→ optimal

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical 20 second trials, 10 second ITI, 30 min. session, once a day = 60 trials/day. Recorded after session 5, brain conditioned.

Total No. of Sessions. 5

S 023

Status. Brain conditioned $p < .005$)correlation)

EBS Rate and Parameters. 142/min. 275 μ A x 250 msec.

Intensity-Rate Curve.

150 μ A	5/min.	
175 μ A	38.1/min.	
200 μ A	88.6/min.	→ used for conditioning
225 μ A	113.7/min.	
250 μ A	134/min.	
275 μ A	141.5/min.	→ optimal
300 μ A	130/min.	

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical - 20 second trials, 10 second ITI, 30 minute session/day = 60 trials/day. Recorded after session 4, brain conditioned.

Total No. of Sessions. 4

SUBJECT NO. 22

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	0	[illegible]	0	0
2	1	5	[illegible]	[illegible]
3	2	[illegible]	[illegible]	6
4	3	6	7	0
5	5	[illegible]	2	[illegible]
6	4	[illegible]	7	3
7	12	[illegible]	7	[illegible]
8	13	[illegible]	11	2
9	10	7	[illegible]	[illegible]
10	5	[illegible]	4	4
11	4	[illegible]	1	7
12	2	[illegible]	7	
13	3.1	1.3	3.3	7.2
14	2.6	2.1	[illegible]	1.8
15	4.1	2.6	[illegible]	3.2
16	1.3	1.2	[illegible]	2.4
17	2	2.1	2.8	2.8
18	1.1	1.1	1.7	2.6
19	1.3	1	1.6	1.2
20	1.1	1.1	3.3	2.5
21	2.2	2.3	1	2.3
22	2.6	.4	2.1	1.8
23	2.0	.5	1.9	2.2
24	2.2	1.9	1.7	3.6
25	2.4	1.4	1.4	3.1
26	2.0	1.4	1.2	2.5

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .486969
PRE-NF VS POST-NF
CORR= .739559
PRE-NF VS POST-F
CORR= .505085
PRE-F VS POST-NF
CORR= .364279
PRE-F VS POST-F
CORR= .345435
POST-NF VS POST-F
CORR= .133619

COND	T
1	.788019
2	-.953639E-01
3	4.76484
4	1.60017
5	.778528E-01
6	1.03419
7	1.49826
8	-.591077
9	1.34952

SUBJECT NO. 23

PERCENT TIME IN HAND

BAND	PRE-NE	PRE-F	POST-NE	POST-F
1	36	36	36	21
2	22	22	17	14
3	19	23	17	28
4	16	11	16	4
5	9	14	13	15
6	5	7	6	3
7	14	9	14	12
8	24	23	19	20
9	23	18	18	16
10	11	14	16	8
11	8	3	6	8
12	9	10	11	11
13	6.4	7	14.3	10.5
14	5.8	9.7	8.6	8.3
15	4.6	6	3.9	7.4
16	1.8	2.1	.7	1.5
17	2.4	3.1	.9	5.5
18	1.6	4	1.1	1.3
19	1.4	2.4	[illegible]	4
20	4.4	5.4	4	5.4
21	4.6	5.5	4.8	5
22	4.6	4.1	4.4	3.3
23	4.3	5.4	6.3	6.2
24	5.1	2.2	6.2	4.3
25	5.1	5.1	5.4	5.2
26	4.3	4.4	4.3	4.2

STATISTICAL DATA

		COND	T
PRE-NE	VS PRE-F	1	2.51699
CORR=	.946892	2	4.02627
PRE-NE	VS POST-NE	3	3.62395
CORR=	.938114	4	3.00028
PRE-NE	VS POST-F	5	1.6217
CORR=	.801519	6	3.54719
PRE-F	VS POST-NE	7	1.526
CORR=	.925175	8	1.76668
PRE-F	VS POST-F	9	2.61019
CORR=	.856682		
POST-NE	VS POST-F		
CORR=	.774359		

S 029

Status. Brain conditioned, $p < .01$ (correlation)

EBS Rate and Parameters, 60/min, 225 μ A x 250 msec.

Intensity-Rate Curve.

150 μ A	15/min.	
175 μ A	21/min.	
200 μ A	40/min.	→ used for conditioning
225 μ A	60/min.	→ optimal
250 μ A	50/min.	

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical. 20 second trials, 10 second ITI. 30 min/session 1 session/day = 60 trials/day . Recorded after 5 sessions - brain conditioned.

Total No. of Sessions 5

S 030

Status. Brain conditioned $p < .001$ (correlation)

EBS Rate and Parameters. 138/min. 250 μ A x 250 msec.

Intensity-Rate Curve.

150 μ A	36/min.	
175 μ A	93/min.	→ used for conditioning
200 μ A	128/min.	
225 μ A	137/min.	
250 μ A	138/min.	→ optimal

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical. 20 second trials, 10 second ITI, 30 minute session, 1 session/day = 60 trials/day. Reinforcement schedule: 100%; 50% during session immediately preceding post recordings. - Recorded after 5 sessions - conditioned.

Total No. of Sessions 5.

SUBJECT NO. 29

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	42	42	21	36
2	17	21	21	14
3	14	14	17	14
4	24	9	20	7
5	8	3	4	11
6	13	6	8	13
7	4	11	11	11
8	10	12	19	15
9	12	13	0	13
10	15	10	12	10
11	9	9	4	6
12	13	13	0	11
13	11.2	9.2	10.5	10.5
14	8.5	10.1	6	10.7
15	8.5	11.1	12.2	6.0
16	2.4	3.9	4.2	3.4
17	2.2	2.2	1.8	.9
18	3	1.3	2	3
19	2.8	3.6	2.8	2
20	2.0	3.3	3.3	1.0
21	4	2	5.3	1.7
22	2.7	4.2	3	4.2
23	3.5	4.3	7	4.6
24	4.4	3.1	3.1	3.1
25	3.1	2.3	4.6	3.2
26	3.2	1.6	3.5	2.2

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .836479
PRE-NF VS POST-NF
CORR= .777777
PRE-NF VS POST-F
CORR= .872781
PRE-F VS POST-NF
CORR= .588209
PRE-F VS POST-F
CORR= .922402
POST-NF VS POST-F
CORR= .629021

COND	T
1	-2.14517
2	-.014234
3	2.2804
4	-1.35832
5	-4.81704
6	-.637931
7	-1.9166
8	-2.27063
9	1.59227

SUBJECT NO. 30

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	36	31	42	16
2	21	21	7	17
3	31	23	23	17
4	16	13	16	13
5	6	9	5	9
6	3	5	3	6
7	4	4	4	7
8	14	15	7	9
9	20	18	12	15
10	11	10	24	10
11	10	10	15	8
12	11	14	10	14
13	11.2	12.5	15.8	11
14	4.8	4.8	7.7	7.1
15	6.4	4.8	6.9	4.8
16	1.5	2	1.5	2
17	.9	1.3	.4	2.3
18	.8	1.3	.4	.8
19	1.2	1.2	.8	.8
20	4	1.8	2.2	2.5
21	2.3	3.6	1	4
22	2.4	3.7	1.2	2.7
23	3.5	3.8	1.9	1.6
24	2.4	2.5	1.4	.7
25	2.3	2.3	2.1	3.1
26	2.8	4	1.2	3.2

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .977373
PRE-NF VS POST-NF
CORR= .859481
PRE-NF VS POST-F
CORR= .826014
PRE-F VS POST-NF
CORR= .835794
PRE-F VS POST-F
CORR= .858135
POST-NF VS POST-F
CORR= .782748

COND	T
1	5.115979
2	6.47954
3	1.26061
4	.543615
5	-.264083
6	.093582
7	.173896E-01
8	.107151
9	4.611749

S 033

Status. Brain conditioned, $p < .001$ (correlation)

EBS Rate and Parameters. 112/min. 275 μA x 250 msec.

Intensity-Rate Curve.

150 μA	63/min.	
175 μA	74/min.	
200 μA	94/min.	
225 μA	99/min.	used for conditioning
250 μA	110/min.	
275 μA	112/min.	optimal

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical. 20 second trials, 10 sec. ITI, 30 min./session, 1 session/day = 60 trials/day - Reinforcement schedule:100%, 50% during session before recording. Recorded after 5 sessions. brain conditioned.

Total No. of Session. 5.

S 034

Status. Brain conditioned, $p < .05$ (correlation)

EBS Rate and Parameters. 38/min, 400 μA x 250 msec.

Intensity-Rate Curve.

350 μA	10/min.	
375 μA	21/min.	used for conditioning
400 μA	38/min.	optimal
425 μA	35/min.	

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt, Air

Conditioning. Standard Classical. 20 second trials, 10 sec. ITI, 30 min/session 1 session/day = 60 trials/day. Reinforcement schedule 100%, 50% prior to recording. Recorded after sessions 5, 8, and 9, Brain conditioned after session 9 - when exposed to Air vs. TNT.

Total No. of Sessions. 9

SUBJECT NO. 33

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	36	36	42	16
2	28	17	7	21
3	23	20	3	20
4	20	13	29	24
5	13	19	17	13
6	3	6	7	6
7	11	6	11	1
8	18	12	18	16
9	18	17	14	22
10	15	16	12	22
11	6	6	6	7
12	5	10	8	11
13	9.9	8.6	11.2	11.8
14	6.5	5.4	10.1	7.7
15	5.3	6.4	6.4	6.4
16	1.5	2.9	2.4	3.4
17	1.4	2.3	3.2	.9
18	1.3	2.6	2.9	4.2
19	.4	1.2	1.2	.8
20	3.3	2.2	3.6	.2
21	3	3.7	4.6	5
22	4.5	2.7	4.2	4.9
23	3.5	3.5	5.1	6.2
24	2.9	4.8	5	4.5
25	4.8	4.4	5.4	4.2
26	3.9	2.1	3.3	2.2

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .924149
PRE-NF VS POST-NF
CORR= .748093
PRE-NF VS POST-F
CORR= .813981
PRE-F VS POST-NF
CORR= .785044
PRE-F VS POST-F
CORR= .761494
POST-NF VS POST-F
CORR= .571851

COND	T
1	3.35057
2	2.2363
3	2.11231
4	-.721392
5	.244088
6	2.39488
7	-.847065E-01
8	-.272419
9	3.27743

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	21	36	21	47
2	10	17	14	28
3	11	6	11	14
4	18	11	25	6
5	11	25	8	23
6	10	7	7	8
7	14	17	18	10
8	20	22	10	15
9	23	13	11	13
10	9	8	9	15
11	4	4	5	5
12	6	5	6	8
13	5.9	4.6	7.9	6.6
14	7.1	4.8	8.3	8.3
15	5.3	7.9	7.4	5.3
16	1	4.9	3.4	4.4
17	1.4	3.2	5.1	4.1
18	2.1	2.6	2.1	3.4
19	2.8	4.4	4.4	2
20	5.1	6.5	6.5	5.9
21	5.3	7	5.3	6.6
22	8.4	12	7.2	7.5
23	7	7.6	10	8.1
24	15	14.1	10	12.7
25	7.9	7.7	5.9	7.1
26	7	5.5	6.3	7.6

STATISTICAL DATA

		COND	T
PRE-NF	VS PRE-F	1	-1.85125
CORR=	.738675	2	1.78487
PRE-NF	VS POST-NF	3	2.29317
CORR=	.818041	4	1.05206
PRE-NF	VS POST-F	5	-2.3421
CORR=	.614023	6	1.3074
PRE-F	VS POST-NF	7	-.704667
CORR=	.680693	8	.385191
PRE-F	VS POST-F	9	.057868
CORR=	.877056		
POST-NF	VS POST-F		
CORR=	.581746		

S 035

Status. Brain conditioned $p < .05$ (correlation)

EBS Rate and Parameters. 90/min. 200 μ A x 250 msec.

Intensity-Rate Curve.

150 μ A _____ 83/min. → used for conditioning
175 μ A _____ 88/min.
200 μ A _____ 90/min. → optimal
225 μ A _____ 79/min.

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical. 20 sec. trials, 10 sec. ITI, 30 min. sessions, 1 session/day = 60 trials/day. R_f schedule: 100%, 50% during session prior to recording. Recorded after sessions 5, 8; Brain conditioned after 8 sessions.

Total No. of Sessions 8.

S 036

Status. Brain Conditioned $p < .05$ (correlation)

EBS Rate and Parameters. 67/min. 325 μ A x 250 msec.

Intensity-Rate Curve.

250 μ A _____ 28/min.
275 μ A _____ 38/min.
300 μ A _____ 38/min.
325 μ A _____ 67/min.
350 μ A _____ 62/min.

Odorants Employed. Pre: TNT, Asphalt - Post: TNT, Asphalt

Conditioning. Standard Classical. 20 second trials, 10 sec. ITI, 30 minute session, 1 session/day = 60 trials/day. Schedule of R_f 100%; 50% during session prior to recording. Recorded after session 5; brain conditioned.

Total No. of Sessions 5.

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	26	5	31	16
2	14	24	24	14
3	6	14	17	31
4	24	27	18	9
5	11	10	9	25
6	18	7	10	7
7	17	25	14	10
8	17	20	12	18
9	6	5	10	16
10	4	10	12	10
11	5	6	9	3
12	8	7	2	4
13	6.6	8.5	6.6	7.2
14	6.5	11.3	11.3	7.1
15	6.9	7.4	6.9	7.4
16	3.4	2.4	3.4	3.0
17	2.8	3.2	2.8	4.1
18	1.7	3.4	5.5	2.6
19	3.6	1.6	4.4	4.7
20	5.8	2.5	3.3	4.4
21	5.3	3.7	4.6	4.3
22	5.4	5.1	6	6
23	6.5	5.9	5.7	7.6
24	8.6	4.8	6.7	7.3
25	7.1	7.5	6	5.3
26	4	4.4	4.4	4.0

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .617678
PRE-NF VS POST-NF
CORR= .743585
PRE-NF VS POST-F
CORR= .346368
PRE-F VS POST-NF
CORR= .579813
PRE-F VS POST-F
CORR= .416055
POST-NF VS POST-F
CORR= .566644

COND	T
1	1.11816
2	1.54308
3	1.27561
4	3.04902
5	1.04443
6	.799499E-01
7	1.74828
8	1.02039
9	.266807

SUBJECT NO. 36

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	26	31	21	42
2	17	31	20	24
3	17	11	23	20
4	9	16	11	24
5	11	13	17	9
6	8	3	0	6
7	10	10	12	17
8	16	22	15	9
9	18	16	13	10
10	16	13	12	8
11	7	8	2	2
12	9	9	4	8
13	7.2	10.5	7.9	7.9
14	7.1	7.1	7.7	8.3
15	5.8	6.4	5.8	9
16	2.4	1	2.4	1
17	1.4	1.8	2.3	3.2
18	.8	2.1	1.7	2.6
19	1.6	2	.8	4
20	3.6	3.3	5.4	2.9
21	2.4	2.3	2.3	4.3
22	4.8	4.5	3.6	3.9
23	6.2	4	1.9	3.5
24	5	6.2	2.6	3.3
25	3.5	4.2	3.1	2.5
26	3.2	2.6	3.5	1.6

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .888533
PRE-NF VS POST-NF
CORR= .844046
PRE-NF VS POST-F
CORR= .796974
PRE-F VS POST-NF
CORR= .868847
PRE-F VS POST-F
CORR= .829068
POST-NF VS POST-F
CORR= .782728

COND	T
1	1.08412
2	1.58485
3	.914091
4	.699614
5	.667653
6	1.46428
7	.169326
8	.807278
9	1.22944

S 037

Status. Brain conditioned $p < .1$ (correlation)

EBS Rate and Parameters. 31/min. 425 μ A x 250 msec.

Intensity-Rate Curve.

350 μ A _____12/min. → used for conditioning
375 μ A _____23/min.
400 μ A _____23/min.
425 μ A _____31/min. optimal
450 μ A _____31/min.

Odorants Employed. Pre: TNT, Pine - Post: TNT, Pine, Air, Asphalt

Conditioning. Standard Classical. 20 second trials, 10 sec. ITI, 30 minute session, 1 session/day = 60 trials/day. R_f schedule - 100%, until session prior to recordings, then 50%. Post recorded after sessions 3, 5, 8, 10, after exposed to all NE odors above - Brain conditioned after 10 sessions.

Total No. of Sessions. 10 .

S 039

Status. Brain conditioned $p < .005$ (correlation)

EBS Rate and Parameters. 50/min. 200 μ A x 250 msec.

Intensity-Rate Curve.

175 μA _____didn't press → used for conditioning
200 μ A_____50/min. → optimum
225 μ A _____26/min.
250 μ A _____40/min.

Odorants Employed. Pre: TNT, Pine - Post: TNT, Asphalt, Air, Pine

Conditioning. Standard Classical. 20 second trials, 10 sec. ITI, 30 minute session, 1 session/day = 60 trials/day. R_f schedule - 100% until session prior to recording, then 50% . Recorded after 3 and 5 sessions; after exposure to all NE odors listed above; brain conditioned after 5 sessions.

Total No. of Sessions 5 .

SUBJECT NO. 37

PERCENT TIME IN BAND

BAND	PRE-NE	PRE-E	POST-NE	POST-E
1	31	42	26	36
2	21	10	21	10
3	17	11	14	22
4	16	20	22	11
5	11	15	4	9
6	2	8	5	6
7	6	17	6	7
8	17	19	16	19
9	18	14	14	23
10	16	11	9	7
11	3	7	7	4
12	8	7	10	8
13	6.6	8.6	10.5	10.5
14	6.6	7.1	11.9	6.6
15	4.8	5.8	6.4	4.8
16	2.4	1.5	5.4	2.9
17	2.8	4.6	1.8	.5
18	2.6	2.6	2.1	1.3
19	1.2	1.2	2.4	.8
20	4	5.4	4	3.6
21	7	7	6.6	5.3
22	5.1	8.1	7.5	6
23	10.8	9.7	9.4	8.1
24	14.8	7.9	8.1	9.3
25	10.8	6.2	6.4	12.7
26	6.9	5.3	6.5	7.9

STATISTICAL DATA

PRE-NE VS PRE-E
CORR= .79738
PRE-NE VS POST-NE
CORR= .861758
PRE-NE VS POST-E
CORR= .867329
PRE-E VS POST-NE
CORR= .75776
PRE-E VS POST-E
CORR= .826714
POST-NE VS POST-E
CORR= .773412

COND	T
1	-.506729
2	-1.19511
3	1.62997
4	-.10017
5	-.925587
6	-.213235
7	.415309
8	-1.12336
9	.212326

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PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	36	31	31	47
2	14	10	21	21
3	14	6	26	8
4	20	13	24	20
5	13	17	8	19
6	10	14	6	11
7	10	10	11	25
8	22	14	23	11
9	21	20	28	11
10	5	10	8	11
11	6	6	3	4
12	4	12	7	1
13	7.9	10.5	6.6	7.2
14	6	4.8	7.7	6.5
15	7.4	5.9	6.9	9
16	4.9	2.4	3.9	5.4
17	3.7	2.3	2.3	4
18	1.3	4.7	2.1	2.6
19	2.8	1.2	2.4	2.4
20	4	5.1	2.9	3.3
21	6.3	3.3	3.3	5.3
22	4.3	4.5	4.5	6.0
23	6.5	5.7	5.4	5.7
24	3.3	5	4.5	7.2
25	2.3	5.4	5.2	3.5
26	3.2	4.4	4.1	3

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .802044
PRE-NF VS POST-NF
CORR= .304375
PRE-NF VS POST-F
CORR= .24945
PRE-F VS POST-NF
CORR= .,106488
PRE-F VS POST-F
CORR= .812233
POST-NF VS POST-F
CORR= .675759

COND	T
1	.951409
2	.631227
3	4.54005
4	1.51375
5	-1.11896
6	.400261
7	1.22921
8	-.961914
9	1.62769

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S 040

Status. Brain conditioned. $p < .001$ (correlation)

EBS Rate and Parameters. 78/min. 175 μ A x 250 msec.

Intensity-Rate Curve.

125 μ A	42/min.	
150 μ A	71/min.	→ used for conditioning
175 μ A	78 min.	→ optimal
200 μ A	73/min.	

Odorants Employed. Pre: TNT, Pine - Post: TNT, Pine, Air, Asphalt

Conditioning. Standard Classical. 20 sec. trial, 10 sec. ITI, 30 minute/session, 1 session/day = 60 trials/day. R_f schedule: 100% until session before recording, then 50%. Recorded post sessions 3, 5, 8, and 10, after exposure to all of above NE odors; Brain conditioned after 10 sessions.

Total No. of Sessions 10.

S 041

Status. Brain conditioned $p < .01$ (correlation)

EBS Rate and Parameters. 42/min., 400 μ A x 250 msec.

Intensity-Rate Curve.

300 μ A	1.6/min.	
325 μ A	14/min.	→ used for conditioning
350 μ A	11/min.	
375 μ A	29/min.	
400 μ A	42/min.	→ optimum
425 μ A	34/min.	

Odorants Employed. Pre: TNT, Air - Post: TNT, Pine, Asphalt, Air

Conditioning. Standard Classical. 20 sec. trial, 10 sec. ITI, 30 minute session, 1 session/day = 60 trials/day. Recorded post session 3, brain conditioned. R_f schedule=100%, 50% during session prior to postrecordings.

Total No. of Sessions 3.

SUBJECT NO. 40

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	24	47	24	42
2	21	21	10	14
3	8	14	8	22
4	22	13	22	6
5	23	8	11	4
6	8	6	6	3
7	11	7	11	11
8	14	12	18	17
9	14	16	13	6
10	10	18	10	16
11	6	8	4	4
12	8	13	6	11
13	3.9	5.5	8.5	5.3
14	10.1	7.7	5.4	8.0
15	5.8	4.8	5.3	12.7
16	4.4	2.9	2.4	2.0
17	4.6	3.7	3.2	1.4
18	3.0	2.1	4.2	.5
19	5.5	2.4	1.2	.8
20	4.7	5.1	6.2	4
21	7.6	2.6	6.6	5.3
22	4.8	3.9	8.1	6
23	5.4	3.8	9.7	8.9
24	7.4	6.7	10.8	9.7
25	6.2	3.7	8.3	9.2
26	3.7	5.1	5.6	4.4

STATISTICAL DATA

		CORR	T
PRE-NF	VS PRE-F	1	-1.53765
CORR=	.731428	2	2.44463
PRE-NF	VS POST-NF	3	1.66409
CORR=	.793914	4	2.44754
PRE-NF	VS POST-F	5	-1.5131
CORR=	.546331	6	.751008
PRE-F	VS POST-NF	7	-.670865
CORR=	.737732	8	1.12705
PRE-F	VS POST-F	9	.237481
CORR=	.45642		
POST-NF	VS POST-F		
CORR=	.681464		

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SUBJECT NO. 41

PERCENT TIME IN BAND

BAND	PRE-NF	PRE-F	POST-NF	POST-F
1	36	31	36	31
2	17	21	21	17
3	8	28	20	6
4	22	13	10	20
5	6	13	9	6
6	2	2	8	10
7	12	5	17	8
8	10	19	23	22
9	15	15	16	16
10	15	13	7	14
11	6	3	4	6
12	4	3	0	7
13	11.2	7.2	9.2	10.5
14	8.9	8.3	10.1	6
15	7.9	6.9	9	5.5
16	1	1.5	3	4.4
17	2.8	1.8	4.1	2.8
18	2.6	1.7	1.3	4.6
19	2.4	1.6	1.2	1.6
20	5.8	4.4	5.4	4.7
21	4.6	5	7.6	5
22	6.6	8.7	7.5	9.6
23	10.5	11.1	10.2	8.1
24	8.1	12.7	11	10
25	10.6	11.2	10.5	11.8
26	6.5	7.4	5.5	7

STATISTICAL DATA

PRE-NF VS PRE-F
CORR= .743752
PRE-NF VS POST-NF
CORR= .840513
PRE-NF VS POST-F
CORR= .867304
PRE-F VS POST-NF
CORR= .858141
PRE-F VS POST-F
CORR= .709927
POST-NF VS POST-F
CORR= .842475

COMP	T
1	.48[illegible]284
2	-1.67879
3	-.3734578-01
4	-.5[illegible]4267
5	2.73252
6	.4270[illegible]8
7	1.13893
8	.1148[illegible]09E-01
9	-.91[illegible]8E

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Discussion

It is clear that rats can detect the odor of TNT. The questions of merit really concern the most efficient techniques to produce a trained TNT detector. We started with the concept that it might be best first to train the rat to bar-press for EBS when TNT was present to have an index that he was indeed aware of the presence of TNT. We felt that once the rat pressed the bar significantly more when TNT was present than for the control odorants, we could be sure of his conditioning and then proceed to recording his CFS.

We achieved such self-stimulation in several rats, and went on to record their CFS. We soon learned that the fact that a rat demonstrated conditioning did not necessarily mean that he would show corresponding changes in his CFS, although some did. Conversely, we also discovered that we could find significant changes in CFS after classical conditioning (viz., stimulating the rat with EBS only when TNT was present) which change could not necessarily predict how well the rat would bar press for EBS when TNT was present.

We, therefore, resolved, fairly soon, that we would not use operant conditioning as an indicator of training, but use classical conditioning exclusively, and record after reasonable periods of training. This procedure worked well. However, the question of <u>when</u> to record was not answered in this study, and must await a new study in which we propose to record after each session of training.

Another question which had to be resolved is which criteria to use in considering a rat capable of distinguishing TNT from controls. In the case of operant conditioning, it was clear: the rat had to avoid pressing the bar when the controls were present and press everytime TNT was present. However, there were problems in deciding when the CFS to TNT was different.

We employed various statistical procedures. The Wilcoxon and Friedman Tests, essentially measured whether there was more cortical activity during TNT than control odorant delivery. This procedure yielded a few cases which confirmed the hypothesis.

However, we ultimately found a more subtle technique. We reasoned that the training should produce a modification of the CFS, when TNT was "learned" to be important, but that the CFS would not change during "unimportant" stimuli. We, therefore, employed Pearson Product Moment Correlations between the CFS obtained prior to and following exposure (and training) to the odorants.

This system of analysis enabled us to evaluate even subtle modifications of the CFS produced by the training.

In order to ascertain whether the changes in CFS shown after training were specific to each rat, or represented a change common to all, we computed an analysis of variance for the following variables: Subject, Pre versus Post, Explosive versus Nonexplosive, Bands of EEG activity, and their interactions (See Appendix for Summary Table). There were numerous significant variables and interactions: Subjects, Explosive versus Nonexplosive, etc. However, the triple interaction (Pre-Post x Exp-N Exp x EEG Bands) was not significant, indicating that the changes in CFS after training were not common to all rats. This finding, however, is not surprising in view of the fact that the rats were not subjected to the same training procedures. We might expect that the next study, in which training procedures are to be more standardized, might show more common changes in the CFS.

Conclusions

Rats can distinguish TNT from control odorants if EBS is delivered during TNT exposure alone. The procedures enabling us to detect when the rat is capable of the discrimination are based upon recording CFS during TNT and control odorant stimulation in the naive rat, and then recording these spectra following conditioning. There is a change in the CFS following conditioning which is detectable by computing correlation coefficients and assessing the statistical significance of this change following training.

This procedure may prove to be an efficient way to detect TNT (or other explosives) in various field situations. We recommend further exploration of the role of various cortical sites in learning the discrimination, and exploration of computer-based means of training and assessing the optimal time and degree of training.

Recommendations

Since it is abundantly clear that rats can detect the odor of TNT, the major questions to be answered are: 1. can we enhance training, 2. are there better sites from which to record the CFS, 3. what methods should be employed to determine when the rat has been conditioned, 4. how can we maintain a high level of discrimination ability in the rat, 5. how long does the training last without reinforcement?

These questions form the basis for our recommendations, which are that we should implement a study to investigate these questions.

Appendix

Surgical Procedure

Male Sprague Dawley rats (250-600 gms) were anesthetized I. P. with Chloropent (chloral hydrate and sodium pentobarbitol), with the following dosages.

wt. in grams	cc Chloropent
250	.75
275	.81
300	.88
325	.94
350	1.00
375	1.06
400	1.13
425	1.21
450	1.29
475	1.37
500	1.45
525	1.53
550	1.61
575	1.63
600	1.77

Supplementary injections (15% of the original dose) were administered as needed. The ears were clipped for identification, and the head was shaved. Mineral oil was applied to the eyes to keep them moist, and tincture merthiolate was applied to the shaved scalp as an antiseptic.

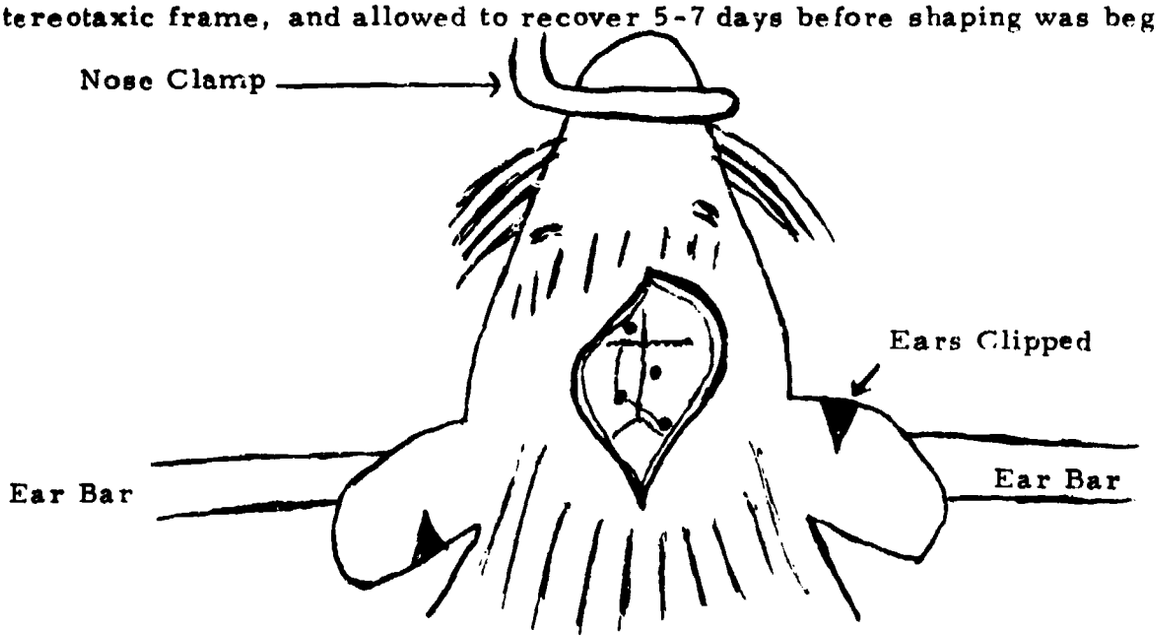
The rat was then placed in a Kopf #900 Small Animal Stereotaxic Instrument as follows: Each ear bar was placed firmly into each auditory meatus, the teeth were placed over the incisor bar, and the nose clamp was tightened. The ear bars were then centered and tightened, so that the rat's head was level and rigid.

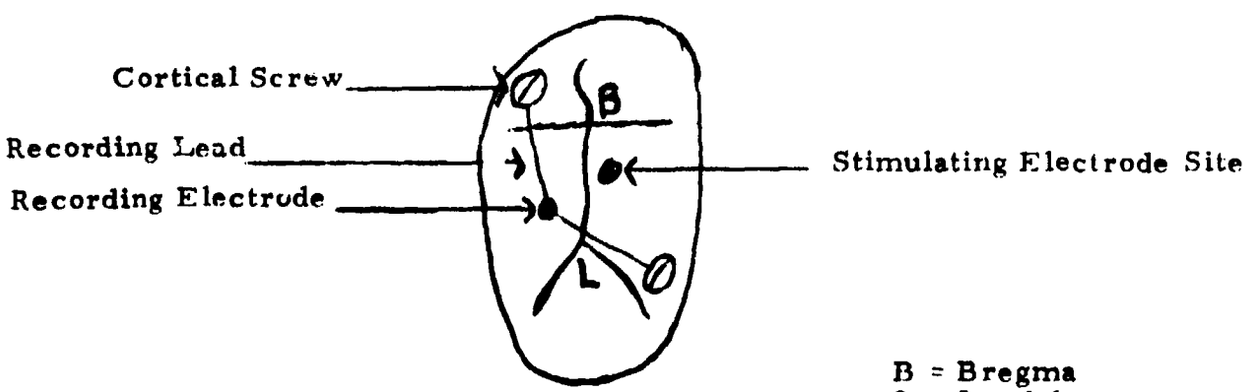
An incision was then made, just lateral to the midline from just behind the eyes to the back of the head (approx. 3/4 in.). The skin was retracted and moistened, exposing the fascia-covered skull. The fascia was then scraped away with a blunt instrument, exposing the landmarks: bregma (anterior) and lambda (posterior). Bregma (B) is the intersection of the frontal and parietal skull plates at the midline and lambda (L) is the intersection of the parietal and interparietal skull plates at the midline. The coordinates for these landmarks were then obtained, and then used for obtaining the coordinates for the stimulating electrode, to be placed in the MFB (medial forebrain bundle). The anterior-posterior (A-P) midpoint is defined as (B+L)/2 and the lateral measurement is the intersection at B or L. The coordinates for the MFB were then defined as follows:

A-P midpoint + 1 mm, lateral distance $\pm$ 1.5 mm, depth= -8.7 mm from skull surface.

The hole for the stimulating electrode was then drilled with a small machine drill with a burr attachment. The holes for the two cortical screws were drilled with a No. 56 machine drill, as far left-anterior and right-posterior as possible (see diagram). A cortical screw (080 stainless steel) was then placed in each hole, and a lead from a bipolar stainless steel electrode, stripped of its insulation, was would tightly around each screw. The electrode was positioned lateral and posterior to the stimulating site, to allow room for the stimulating electrode (see diagram).

The dura was then sliced with a fine (30g) hypodermic needle. The stimulating electrode (stainless steel, bipolar, insulated to the tip, approx. 1 cm. in length) was then lowered to the proper depth. Dental acrylic was then applied, making sure the skull was dry. The acrylic was applied so that it covered the entire exposed surface of the skull, as well as the cortical screws, the recording leads, and 1/2 to 3/4 of the electrode base. The acrylic was allowed to dry hard, and the electrode holder was removed. Two or three stitches (OO surgical silk) were used to close the wound as needed, and antibiotic ointment (Bacitracin or Mycitracin) was applied liberally to the wound to minimize the possibility of infection. The rat was removed from the stereotaxic frame, and allowed to recover 5-7 days before shaping was begun.



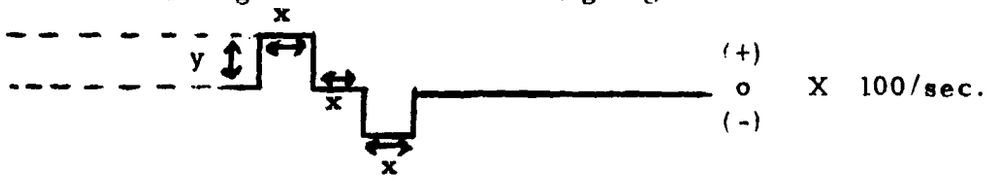


B = Bregma
L = Lambda
Note: Diagram Not Actual Size

Appendix

Shaping Procedure

Shaping was begun 5-7 days postoperatively if the subject seemed healthy. Stimuli were delivered by a Nuclear Chicago Model 7150 Constant-Current Stimulator, or by a 60 Hz sine wave stimulator. The Nuclear Chicago delivered a square-wave stimulus, with the following parameters: .2 msec, "+" going, .2 msec off, .2 msec "-" going, equally spaced at 100 presentations per second. The amplitude, or intensity, of the stimulus is the height of the "+" (or "-") going wave (see illustration).



x= .2 msec.
y= _?_ μ A duration train = ___?___msec.

The stimulus was delivered at a specific amplitude (y), and duration. Amplitudes ranged from 50μA to 600μA, and duration was usually 250 msec, with the exception of two subjects; one was 200 msec, the other, 500 msec. The sine wave stimulator delivered a constant current (no delay) 60 Hz sine wave stimulus, ranging from 50 mV to 400 mV, and was used only in shaping.

Starting at 50μA x 250 msec, a stimulus was delivered to the rat when it approached the bar. Current was raised as necessary (if S was disregarding the stimulation) until an orienting response was elicited while S was engaged in grooming. Then the subject was reinforced for approaching the bar, for sniffing the bar, for touching the bar, and finally for pressing the bar. This procedure, which requires some skill, took from 5 minutes to several sessions of 30 minutes. The animal soon developed a steady routine or a method that allowed him to get the greatest number of stimulations within a period of time. Shaping was terminated when the S pressed at least 10 times/min, for 5 consecutive minutes, for 2 days; then prerecordings were taken, prior to conditioning.

Recording Procedure

Prerecordings. EEGs were taken from each rat prior to conditioning. The S was placed in the testing chamber with no bar, and allowed to become accustomed to the air coming out of the tubes (3-5 minutes). He then was exposed to TNT for 10-20 seconds and EEGs were taken, then the nonexplosive odor for 10-20 seconds, and EEGs were taken. The order of presentation of the odors was random for each rat. EEGs were taken by a stainless steel bipolar electrode attached to two cortical screws on the rat's head (described earlier). The signal was amplified by a Grass Model 7P3A A.C. Pre amp, and Grass Model 7 DAB D.C. Driver Amplifier, and filtered at .3-75 Hz. The EEGs were recorded on either an AMPEX SP300, or a Honeywell 7600, at 1-7/8 i.p.s. with a voice mark and a 3 volt trigger.

Postrecordings. Techniques varied according to the conditioning procedure used. In general, the EEGs were recorded, in the manner described above, at the end of a conditioning session, during which the animal had received stimulation while smelling TNT. Recordings are done without the brain stimulation, during the last few trials of the chosen session. Instrumentation and techniques were identical to those described for prerecording.

Appendix

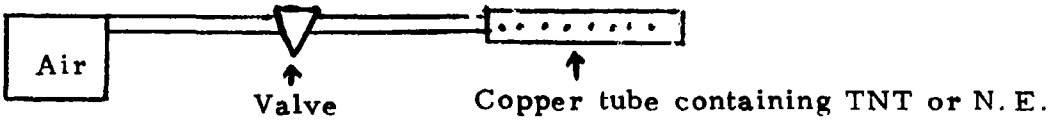
Conditioning Procedure

Several changes in procedure and technique were made in conditioning. Behavioral Conditioning was tried first, before we changed only to classical conditioning. These changes in procedure are outlined chronologically below, beginning with behavioral conditioning, and ending with classical.

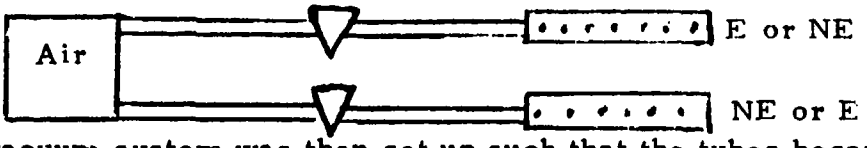
1. Behavioral Conditioning Overview. The S was placed in a testing chamber containing bar. S was exposed to TNT odor for the entire duration of the TNT trial, and nonexplosive odor for the entire duration of the nonexplosive trial. These trials were separated by a 10 second intertrial interval (ITI). A circuit was set up such that S could receive brain stimulation only when pressing the bar during the TNT trial. An exhaust fan, which was continuously on, evacuated the test chamber of air during the ITI. A timer controlled the session length, and separate timers controlled the trial and ITI lengths. Data (responses, number of trials, etc.) were recorded on both counters and cumulative recorder chart paper.

2. The air delivery system underwent a number of changes as follows:

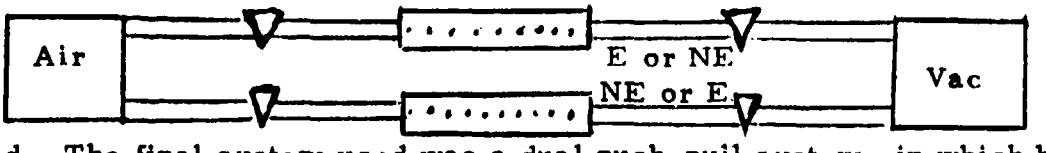
a. Initially, one positive pressure air delivery system was used to present the S with TNT or nonexplosive odorants which were contained in closed-end copper tubes perforated to allow passage of air. The experimenter manually switched the tubes during the intertrial interval, placing them underneath the test chamber.



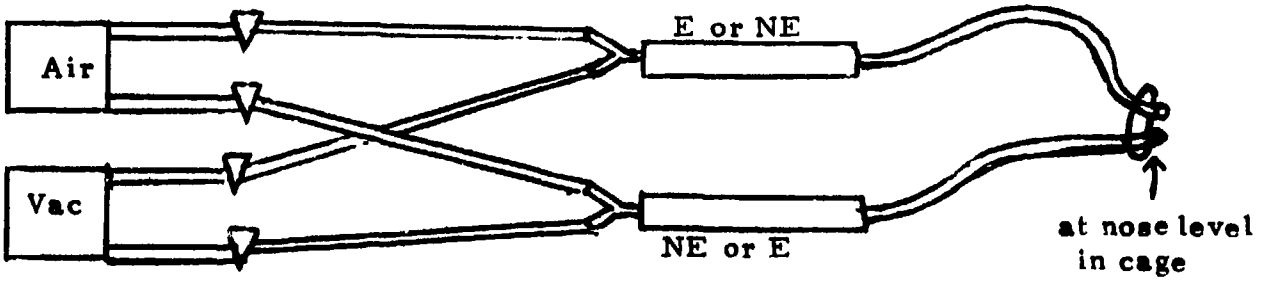
b. This procedure was replaced by a dual positive pressure (dual-push) system, with one tube for each odorant. The odorants were now switched automatically by a logic circuit and probability generator, which presented the odors randomly.



c. A vacuum system was then set up such that the tubes became double-ended, with air entering through one end and a vacuum pulling on the other end. During an explosive trial, air would blow on the TNT and the vacuum would pull on the nonexplosive tube, and vice-versa during the nonexplosive trial. During the ITI, vacuums would pull on both tubes, eliminating both TNT and nonTNT odorants simultaneously.



d. The final system used was a dual push-pull system, in which both vacuum and air tubes were attached at one end of the odor tube, and the other end was open leading to a small opening in the test chamber at nose level. The logic and probability generator were the same as before. In all air systems, pressures of 1 psi or less were used.



For each session the air and vacuum tubes were switched so that the clicking of the solenoid valves could not enable prediction of the odor to be presented next.

3. Actual Conditioning

a. Initial. Trials were presented by hand as described above. They were 1 minute trials, 100 trials/session, 1 session/day. 10 Hz clicks over a small speaker in the test chamber signalled the presence of TNT and thus the availability of EBS. White noise over the same speaker was used as punishment when S pressed the bar during a nonTNT trial. Only 1 rat was used in this system (S 000), and he was behaviorally conditioned.

b. 4/76. The system became automated with the logic and timers mentioned earlier; solenoid valves for the air, and a probability generator to change the odors randomly. The air system used was the dual push-pull system. Ss were split into 5 groups, with varying trial times, punishment, and visual and auditory cues (see Table 1). Punishment took the form of white noise over the speaker with a bar press during a nonTNT trial, or a yellow light flash with the incorrect bar press. (The light was a small 28V, 2.8 watt pilot light attached to the top of the testing chamber). It was later determined that the hiss (white noise) was the more effective punishment. The R_f (Reinforcement) schedule approximated FR(2); that is, the rat was reinforced approximately for every other press. A light (previously described) was used to indicate an intertrial interval. It later proved unsuccessful because the rats cued to its offset rather than to the odorants themselves. The light was also used as a signal of the end of an explosive trial, flashing bright yellow as the trial ended. 10 or 1,000 Hz clicks were used to signal the presence of TNT, as before. It was found that several rats learned the clicks, but then their performance deteriorated as the clicks were faded. Hence, the clicks were later abandoned, and the simple air delivery of the odor was considered a sufficient cue. A summary of this information is contained in Table 1. The system was set up such that the rat had to learn the clicks first (pass at $p < .01$), the clicks were then faded, and the rat was considered conditioned if it passed ($p < .01$) with no auditory cues. No rats passed this procedure.

c. 5/3/76. The groups were expanded and altered. New additions included:

1. A 2-3 second delay in clicks, to allow odor to be presented first.

2. A classical group in which there was no bar, and the rats prerecorded rate was played back to him in the presence of TNT. This will be described more fully later.

3. A new "continuance" trial group. If the subject responded within 20 seconds he was rewarded or punished, depending on the odor, with a trial extension to 60 seconds. If he did not respond within 20 seconds, the trial ended.

4. Rats were given 8 days maximum to pass each stage (clicks, click fading, etc.). Those who did not pass were left dormant. This information is summarized in Table 2.

d. 5/17/76. We decided that 60 minute sessions were too long, since rats seemed to do well in the first 30 minutes, then deteriorated during the last 30 minutes. The number of groups was reduced to 4: 3 behavioral groups and 1 classical group, arranged as follows:

1. Behavioral: 2 30 minute/session groups, 1 group run 2 sessions/day.
   1 15 minute/session groups, 2 session/day
2. Classical - as previously described

e. 5/28/76.

1. A 3 second delay in reinforcement was now instituted. That is, a rat could not receive EBS during the first 3 seconds of a trial (to allow time to detect odors). Any presses in this 3 second interval were counted as ITI presses.

2. Continuance trials were now adapted to each rat, according to its optimal rate of responding, determined during the shaping process. The faster the rate of responding the shorter the time to respond, and the shorter the trial. (See Table 3). Two rats (S 004 "Speedy," and S 020) learned behaviorally ($p < .001$) on this system, which now appears to be the best system to use in behavioral conditioning.

f. Final System. A total switch was made to classical conditioning. This system as described briefly below, produced 18 rats who are considered trained to a statistically significant degree, to demonstrate differential brain activity to TNT versus nonTNT odorants.

General Procedure

1. Shape, as described earlier.

2. Take Rate-Intensity function. Starting on the lowest parameters with which a rat will press, his press rate (per minute) over 5 minutes at increasing intensities is taken, until the rate levels off or drops. In this way, the optimal intensity is determined.

3. The rat's rate is recorded on magnetic tape over 45 min. (approximately) at his optimal intensity, in order to obtain his optimum rate of pressing.

4. Conditioning is run at an intensity somewhat lower than the individual's optimum. The circuit is set up so that the rats recorded rate (playing constantly, channeled through an audio threshold detection relay Scientific Prototype 761-G), triggers the Nuclear Chicago to stimulate the subject only during a TNT trial. The system is set up as before with the last air system described, probability generator, etc. The procedure was set up as follows:

a. 20 second trials, 10 second ITI, 60 trials/session, 1 session/day. 3 second delay in reinforcement.

b. R_f schedule: 100% until trial before post recordings, then 50%.

5. Post Record EEGs last trials (TNT & NE) of session, analyze.

Appendix

Analysis of Effect

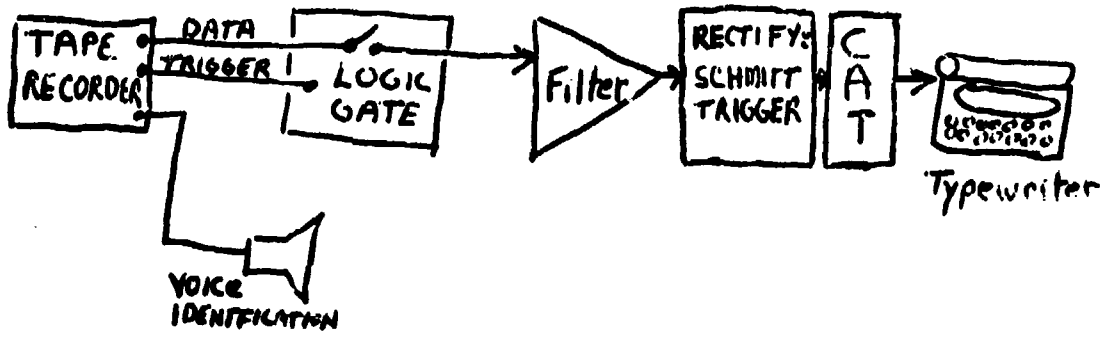
1. Behavioral

Subjects were considered behaviorally conditioned if we found statistically significant different distributions of their likelihood to bar press during explosive and nonexplosive trials. The tests used were one tail; statistical tests were employed only if the likelihood to respond during explosive stimulation was greater than that during nonexplosive stimulation. A Chi Square test was employed as shown.

	E	NE
R	A	B
NR	C	D

where: A indicates the number of trials the S responded during an explosive trial
B indicates the number of trials responded to by barpressing during a non-explosive
trial: C indicates the number of trials the S failed to bar press during explosive odorant
D indicates the failure to respond to nonexplosive trials
Note: a trained rat will have high proportion of trials in A & D category.

Data were recorded on either an Ampex FM recorder (SP-300 or a Honeywell FM recorded Model 7600). Data were identified by voice and by a trigger on separate channels. Once the location on the tape was located via verbal identification, tape speed was switched from 1-7/8 ips to 15 ips (1:8 time compression) and data were automatically collected. A timing circuit was triggered by the first trigger and at least 1,000 msec of compressed time was analyzed. A rectifier and Schmitt trigger unit accepted voltages of at least .1 volt and at least 8 Hz. Baseline crossings were converted into time intervals: time intervals were converted into a histogram by the CAT MNEMTRON models 400B, 600, 522A, 520) in the H. program. (H program starts a sweep upon a baseline pulse and sweeps across addresses at a constant rate of 3.2 KHz until another crossing takes place. It then deposits a count in the current address and resets; thus, a histogram of timed intervals between baseline crossings is accumulated). The histograms were digitally printed out and 26 bands of frequencies were formed by combining proper CAT addresses. (See Appendix, a data sheet, labled "26 Band EEG frequency").



The analysis system is shown in above Figure. At first the filter was set at 320 Hz, low pass, to pick up all frequencies < 40 Hz. Later, to stabilize data for DC shifts we employed a filter set at (.5, 320) Hz [-3dB pts @ - 24 db/octave roll off]. This procedure detects the frequency of simple wave forms, such as sine waves, well. However, we noted visually complex waves (summed sine waves of different frequencies) in the EEG and took measures to separate these frequencies. We first filtered for 1-6 Hz and 6-36 Hz; then decided upon 1-2 Hz 2-4 Hz 4-8 Hz, 8-18 Hz, and 16-38 Hz. Data collected outside the filtered for band were not recorded. Per cent time in band, was:

(a)

$$100\, C_i / \left(F_i \sum_{j=1}^{26} (C_j / F_j)\right)$$

(b)

$$50\, C_i / (F_i t)$$

C_i = counts in band i

F_i = mid Frequency (Hz) of band i

T = time of data sample

These formulas are theoretically equivalant for simple waves but formulation (b) accounts for data outside the bands we analyzed. Pre and postrecordings were always consistently analyzed according to (a) or (b).

Wilcoxon's or Friedman's statistical tests tested the hypothesis of differential occurrence frequencies across all bands. Limited band Wilcoxon's were also performed on the higher frequencies. Correlations were taken preexposure to conditioning and at various times postexposure. T tests were performed to see if conditioning had taken place. If and when this happened the S was considered conditioned to detect TNT.

Table 1

April 1976

	Gp A n=4	Gp B n=4	Gp C n=4	Gp D n=4	Gp E n=4	
ITI time	10 sec.	10 sec.	10 sec.	10 sec.	10 sec.	
Trial time	50 sec.	20 sec.	50 sec.	20 sec.	20 sec.	
Ex	50%	50%	50%	50%	50%	
NEx	Asphalt lst	Asphalt lst	Asphalt lst	Asphalt lst	Asphalt lst	
Pm	No	No	1 second yellow light flash	1 second yellow light flash	Hiss (white noise)	
R_f Schedule	FR (2)	FR (2)	FR (2)	FR (2)	FR (2)	
# Trials / Session	60/1hr.	60/1/2 hr.	60/1hr.	60/1/2 hr.	60/1/2 hr.	
Sessions / Day	1	1	1	1	1	
Days/wk	5	5	5	5	5	
ITI signal	Dim yellow light	Dim yellow light	Dim yellow light	Dim yellow light	Dim yellow light	
Intro. w/click = Ex	X	X	X	X	X	
Signal End Ex trial	Bright Yellow (1 sec.)	Bright Yellow (1 sec.)	Bright Yellow (1 sec.)	Bright Yellow (1sec.)	Bright Yellow (1 sec.)	

* Air-vacuum tubes were switched each day, to minimize predictability of solenoid sounds and specific odors.

Table 2

May 3, 1976

	Gp A	Gp B	Gp C	Gp D	Gp E	Gp F	Gp G	Gp H (classical)
ITI time	10 sec	10 sec	10 sec	10 sec	10 sec	10 sec	10 sec	10 sec
Trial time	50 sec	20 sec	50 sec	20 sec	50 sec	20 or 50 sec	50 sec	20 sec
Ex	50% TNT	50% TNT	50% TNT	50% TNT	50% TNT	50% TNT	50% TNT	50% TNT
NEx	Asphalt 50%	Asphalt 50%	Asphalt 50%	Asphalt 50%	Asphalt 50%	Asphalt 50%	Asphalt 50%	Asphalt 50%
Pm	No	No	Hiss	Hiss	---	Hiss	Hiss	---
R_f	FR(2) final stage	FR(2) final stage	FR(2) final stage	FR(2) final stage	FR(2) final stage	FR(2)	FR(2)	---
No. trials session	60 1 hr	60 1/2 hr.	60 1 hr	60 1/2 hr.	15 15 min.	15 15 min	15 15 min	60 1/2 hr
Session/ Day	1	1	1	1	2	1	1	1
ITI signal	Dim yellow	Dim yellow	Dim yellow	Dim yellow	Dim yellow	Dim yellow	Dim yellow	
Intro w/ clicks =TNT	X	X	X	X	X	no	no	no
End Ex trial	Brt. yellow (1sec)	Brt. yellow (1 sec)	Brt. yellow (1 sec)	Brt. yellow (1 sec)	Brt. yellow (1 sec)	Brt. yellow (1 sec)	Brt. yellow (1 sec)	---

Appendix

S's Not Completed * (Died, Lost Electrical Caps, etc.)

S	SS Rate	Parameters	Type of Cond. Level Reached	Reason for Loss
000	35/min.	300μA x 250 msec.	Behavioral, p< .01, no rec'ds	Died, brain infection
001				Lost Electrical Cap
002				Lost Electrical Cap
003	16/min.	250μA x 250 msec.	Behavioral, then class. no sig.	Lost Electrical Cap Before Post Recordings
007	105/min.	325μA x 250 msec.	Behavioral, 24 days, p< .1, no rec'ds	Died, unknown cause
008	32/min.	600μA x 250 msec.	None	Lost Electrical Cap
009	18/min.	250μA x 250 msec.	None	Lost Electrical Cap
010	53/min.	225μA x 250 msec.	None	Lost Electrical Cap
011				Aversive to EBS
012	122/min.	225μA x 250 msec.	Classical, 2 sessions, no sig.	Died, unknown cause
013	43/min.	350μA x 250 msec.		Lost Electrical Cap
015	116/min.	350μA x 250 msec.	Behavioral, 2 sessions no sig.	Lost Electrical Cap
018	154/min.	275μA x 250 msec.		Lost Electrical Cap
024	47/min.	500μA x 250 msec.		Died, Disinfectant Poisoning ?
025				Not Recordable, 60 Hz Noise
026	119/min.	225μA x 250 msec.		Died, Disinfectant Poisoning
027				Died, Post Op.
028				Died, Post Op.
031	57/min.	350μA x 250 msec.	Classical, 3 sessions, no rec'ds	Lost Electrical Cap Before Post Recordings
032				Lost Electrical Cap

* Not included - S. 038 and S. 42 - Ran, but did not learn

S:_____ DATE REC:_____ CONDIT.:_____

STUDY I.D.:_____ DATE ANAL:_____ REC. #:_____

BY:_____

Anal. run @ 8X real time compression

400 pts. sampled in 125 msec (3.2 kHz)

26 BAND EEG FREQUENCY

CAT ADDRESS	BAND NUMBER	COUNTS	2X F mid	COUNTS 2X F mid	PERCENTAGE		
						U.F.	L.F
6	26		70.9			38.5	32.4
7	25		60.1			32.3	27.9
8	24		52.3			27.9	24.5
9	23		46.3			24.5	21.9
10	22		41.5			21.8	19.7
11	21		37.6			19.7	17.9
12	20		34.4			17.9	16.5
13	19		31.6			16.4	15.2
14	18		29.4			15.2	14.2
15	17		27.2			14.1	13.2
16	16		25.6			13.2	12.4
17-18	15		23.6			12.4	11.1
19-20	14		21.0			11.0	10.0
21-22	13		19.0			9.9	9.1
23-24	12		16.7			9.0	8.3
25-26	11		16.7			8.3	8.0
27-29	10		14.4			7.7	6.9
30-33	9		12.8			6.9	6.6
34-40	8		11.0			6.5	5.0
41-50	7		9.0			5.1	4.0
51-56	6		7.6			4.0	3.6
57-66	5		6.6			3.6	3.1
67-80	4		5.6			3.1	2.4
81-100	3		4.4			2.4	2.0
101-134	2		3.6			2.0	1.5
135-201	1		2.4			1.5	1.0

*U.F = Upper cut off frequency in Hz.

L.F = Lower cut off frequency in Hz.

Appendix

Summary Information

Total Subjects: 43

Self Stimulation

Total Self Stimulators: 36

Intensity Range: 175 μA - 600 μA, mean: 310.4 μA

Duration: 250 msec; 1 rat 500 msec, 1 rat 200 msec.

Rate of S.S.: From 16 presses/min. to 190 presses/min., mean: 76.6/min.

Behavioral Conditioning

Total Subjects: 12 - includes rats later switched to classical conditioning

Total Significant: 1 - by behavioral indices only
1 - by neurophysiological indices only
2 - by both behavioral and neurophysiological indices

Classical Conditioning

Total Subjects: 23 - includes rats which were originally behaviorally conditioned

Total Significant: 18

Number of Sessions Needed to Condition: Ranged from 3-16 sessions with a mean of 7.5 sessions.

Total Conditioned: (Neurophysiological)	21
Total Died or Lost Cap	20
Total Non-Conditioned	2
	43

APPENDIX

Summary of ANOVA for Relative Cortical Activity within Each Frequency Band as a Function of Stimulation (E vs NE) and Condition (Pre vs Post)

SOURCE	DF	SS	MS	F	p
Subjects	20	16155.9	807.794	17.25	.001
A(Pre-Post)	1	23.6	23.562	1.83	
B(NE-E)	1	9.2	9.25	.40	
C(Bands)	25	54318.3	2172.73	46.39	.0001
A X B	1	2.3	2.37	.05	
A X C	25	253.4	10.14	.77	
B X C	25	578.1	23.12	1.79	.02
A X S	20	148.1	7.41	.54	
B X S	20	121.6	6.08	.44	
C X S	500	23414.5	46.83	3.64	.002
A X B X C	25	201.6	8.07	.82	
A X B X S	20	153.3	7.67	.78	
A X C X S	500	6439.2	12.88	1.32	.02
B X C X S	500	6826.5	13.65	1.40	.01
A X B X C X S	500	4893.4	9.79		
TOTAL	2183	113539.0			

Glossary of Abbreviations

EEG =	Electroencephalography
CFS	Cortical Frequency Spectra
EBS	Electrical Brain Stimulation
MFB	Medial Forebrain Bundle
Pre-E; Pre NE	Prior to Explosive or Nonexplosive exposure
Post-E; Post NE	Following Exposure to Explosive or Nonexplosive
r =	Pearson Product Moment Correlation
t-test =	Student's test for differences
Ex, NEx =	Explosive, nonexplosive
X^2 =	Chi Square test
S =	Subject (given with identification number)
R (or Re)	Response (to bar press)
NR (or NoRe) =	No response (to bar press)
ANOVA =	Analysis of Variance

APPENDIX

Percentage Time in Each Band Recorded During Pre- and Post- Explosive and Non-Explosive Conditions

BAND	PRE-NE	PRE-E	POST-NE	POST-E
1	23.4762	23.0476	22.0476	24.2381
2	14	15.4762	12.9524	11.7143
3	12.8571	14.6667	13.1429	14.2381
4	14.9048	12.3333	16	10.6667
5	9.42857	11.619	8.28571	10.3333
6	6.61905	5.14286	5	6.14286
7	11.5238	12.0952	11.3333	11.2857
8	15.8095	14.9524	15.5714	12.9048
9	13.5238	11.9524	11.8095	12.0952
10	9	9.28571	8.71428	9.14286
11	5.28571	5.61905	4.57143	4.23809
12	6.47619	7.57143	6.61905	6.90476
13	6.21904	6.67619	7.15238	7.57619
14	6.0619	5.82856	6.37142	6.55237
15	5.23809	5.47618	5.73809	6.07142
16	2.2619	2.39047	2.47619	2.61428
17	2.29999	2.35237	2.35714	2.54761
18	1.89523	2.47142	2.07619	2.30952
19	2.09047	2.4619	2.13333	2.05714
20	3.84285	3.34761	3.59999	3.78095
21	3.99047	3.77142	4.17619	4.35237
22	4.45237	4.7	4.55714	4.7619
23	5.18095	4.97619	5.88095	5.50952
24	5.66666	5.15238	5.70952	5.56666
25	4.82856	4.5238	5.11428	5.14285
26	3.75238	3.68571	3.61428	3.74761

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Table 3
Continuance Trials As a Function of Subjective Time

Let x = rate of responding

Let y = time to respond

k = number of reinforcements obtainable in y time:
a measure of likelihood to respond in time y.

Given: x = 30/min., y = 20 sec. and learning;
x = .5/sec.
xy = k; let k = 10, find y.

x (per min.)	y (in sec.)	Trial Time (Delay + 3XTime to Respond
30	20	63 sec
60	10	33
80	7.5	25.5
90	6.7	23.1
100	6	21.0
110	5.4	19.2
120	5	18.0
130	4.6	16.8
140	4.3	15.9
150	4.0	15.0
160	3.8	14.4
170	3.5	13.5
180	3.3	12.9
190	3.2	12.6
200	3	12.0